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LABOR REQUIREMENTS OF DAIRY FARMS AS INFLUENCED BY MILKING MACHINES.

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It is the object of this bulletin to present the results of studies of the organization of dairy farms, made with special reference to the economic status of the milking machine. The use of the mechanical milker directly affects farm organization through its bearing upon the amount and distribution of labor required by the farms. In general farming labor efficiency is secured by the production of crops in combination with such other farm enterprises as will provide a nearly uniform amount of work throughout the year. There is no constant determining factor as to labor requirements. On the farm which receives the major part of its income from dairy products, however, the dairy alone is generally the determining factor. Any marked saving of labor effected on such a farm must be made in the production or handling of milk, hence the significance of the milking machine as a factor in the organization of the dairy farm.

The data upon which this bulletin is based were secured from 109 New York dairy farms, 56 of which were using mechanical milkers, and from 160 dairy farms in Ohio, Michigan, and Illinois, of which 100 were using milking machines. On the New York farms dairying

Note.—This bulletin is of interest to dairymen generally, and especially to those having herds of over 15 head of cows.

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constituted 90 per cent or more of the total farm business. The farms studied in Ohio, Michigan, and Illinois devoted considerable time to general farming as well as to dairying.

FACTS BROUGHT OUT.

The following is a brief summary of the more important facts developed by this study:

The time saved by the use of the mechanical milker increases with increase in the size of the herd.

With herds of 15 cows or less the average time required to milk a cow by hand is a fraction over 7 minutes; by machine a fraction under 5 minutes.

With herds of over 50 cows it takes slightly under 7 minutes to milk a cow by hand and but 4.15 minutes by machine.

With herds of over 50 cows one man with a machine milks on the average about 28 cows per milking as against 17 where the milking is done by hand.

With increase in the size of the herd the cost per cow of hand milking changes very little, while the cost per cow of machine milking decreases rapidly.

With herds of 15 cows or less the average cost of milking per cow by hand is $10.91 per year as against $10.45 in herds of 50 or more.

With herds of 15 cows or less the average cost of milking per cow by machine is $11.77 per year as against $7.34 for herds of 50 or over.

Although with the average small herd of 15 cows or less it costs more per cow to milk by machine than by hand, it does not follow that the machine is necessarily an unprofitable investment on all farms on which such small herds are kept. On 32 farms having herds of 15 cows or less the use of the mechanical milker was found to effect an annual saving in hired labor of $2.63 per cow through the dropping of hands who had been kept primarily to do the milking.

SOURCES OF DATA.

As is shown in figure 1, the dairy industry is very widely distributed over the United States. In its more intensive forms it is, however, confined to areas which are in close proximity to large cities. The extent of these areas is determined by the city market, the transportation facilities afforded, and the adaptability of the region to dairying. Thus we have, for example, New York City, which requires a large supply of fresh milk for daily consumption. In many sections the rough, hilly country of New York and New England is better adapted to the dairy industry than to other types of farming (see fig. 2). Transportation facilities have been perfected so as to enable the shipping of fresh milk from the extreme northern part

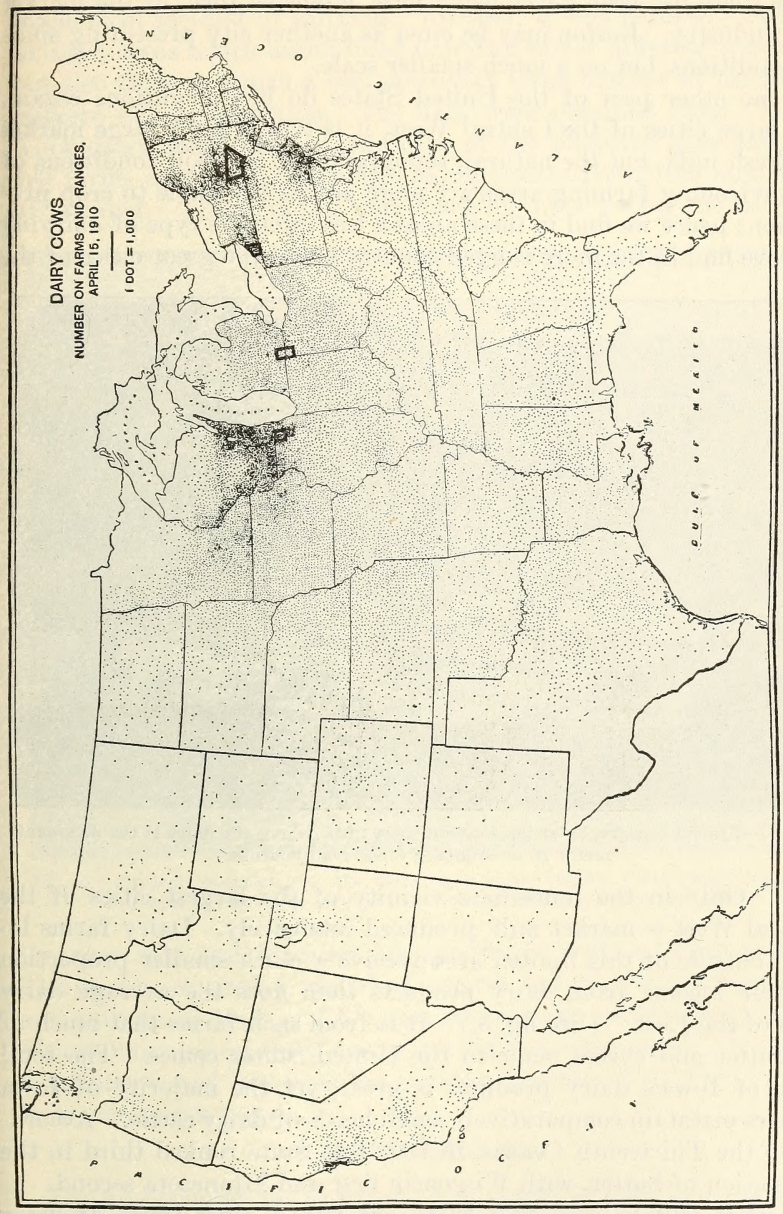

FIG. 1.—Map showing the distribution of dairy cows on farms and ranges in the United States. The areas in which data were obtained for this study are inclosed in heavy black lines.

of New York and as far west as the Finger Lake district. In this entire area all of the above three conditions—market, adaptability of the area to dairying, and transportation facilities—are present; hence there has been developed a most intensive form of the market milk industry. Boston may be cited as another city presenting similar conditions, but on a much smaller scale.

In no other part of the United States do like conditions obtain. The large cities of the Central West, it is true, offer a large market for fresh milk, but the natural, topographical, and soil conditions of the environing farming areas are more or less favorable to crop production; hence we find in these areas a less intensive type of dairying than we find in the more rugged country about the great cities of the

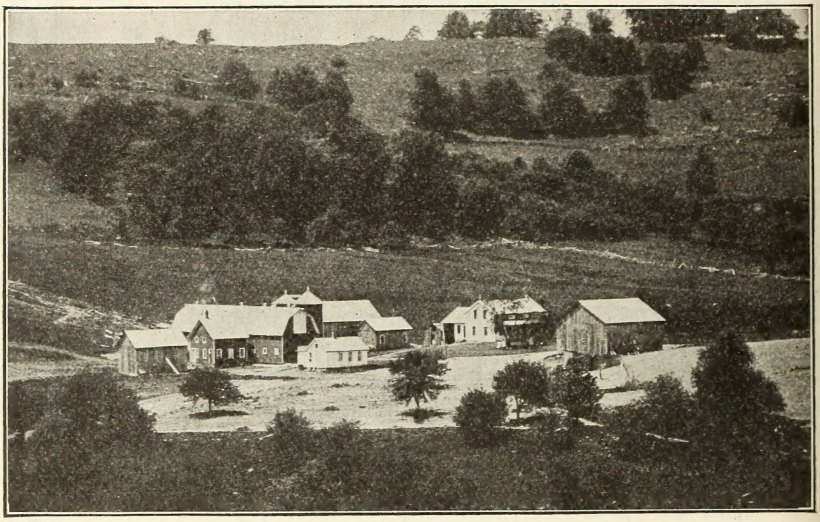

FIG. 2.—Typical topography of the Eastern dairy farm, where the dairy is the dominant factor in determining labor requirements.

East. Only in the immediate vicinity of the largest cities of the Central West is market milk produced intensively. Dairy farms located outside of this limited area receive a much smaller proportion of their income from dairy products than does the average dairy farm of the East. (See fig. 3.) It is from such farms that much of the butter and cheese made in the United States comes. The total value of Iowa's dairy products is great, yet the majority of Iowa farmers maintain comparatively small herds of dairy cattle. According to the Thirteenth Census, in 1909 this State ranked third in the production of butter, with Wisconsin first and Minnesota second.

Thus it will be seen that there are two distinct types of dairy farming in vogue in this country—the strictly dairy type of the comparatively rugged Northeastern States and the mixed type which prevails throughout the dairy regions of the Middle West.

In order to determine the effect of the milking machine upon the organization and economic management of the dairy farm in general, it was necessary to secure data from farms of both these types as well as from farms representative of both the hand and the mechanical method of milking. Further, it was necessary not only to select areas which exemplified dairying under different conditions, but also those in which a comparatively large number of mechanical milkers was in operation. The data were obtained from 109 New York dairy farms as representative of the intensive type and from 160 farms in the Central States as representative of the mixed type of farming. These studies were made by interviewing the dairyman

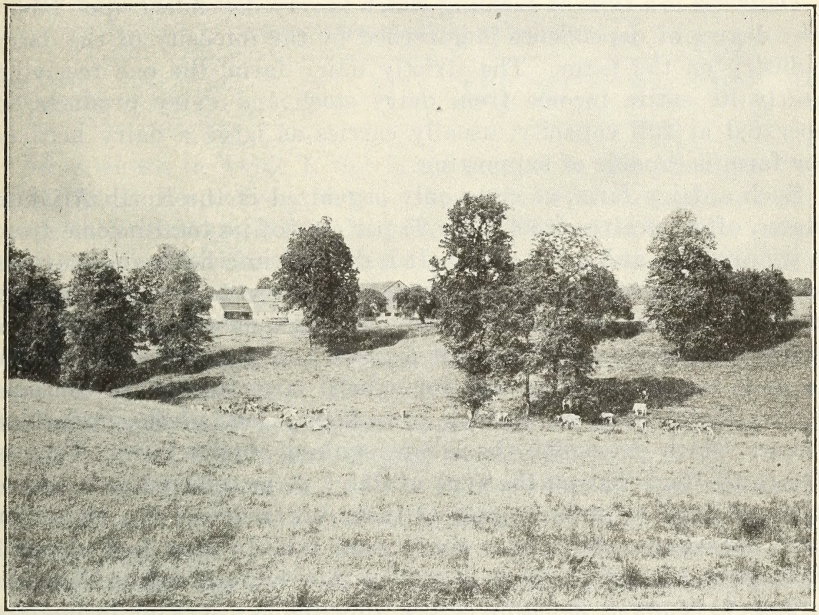

FIG. 3.—Typical topography of the dairy farm of the Middle West, where conditions are more favorable to crop production than on the Eastern dairy farm.

in every case and learning his experience with milking machines. The studies covered a period of several months during the summer and autumn of 1915, and the data secured are representative of conditions existing on these farms during the entire year. The dairymen interviewed had used the milking machine for periods varying from one to six years.

AREAS STUDIED.

The areas chosen for this study are located in Delaware, Chenango, and Chautauqua Counties, N. Y.; Lenawee County, Mich.; Fulton County, Ohio; and McHenry County, Ill. Dairying in a very intensive form is practiced in the New York areas. In the Ohio and

Michigan localities dairying is combined with general farming. In McHenry County, Ill., the dairy is a more important part of the farm business than in the Ohio–Michigan area, but it does not assume as large a proportion of the total farm business as on the farms studied in the New York counties. All of these localities are adjacent to large cities, and the bulk of the milk produced is sold to local creameries, which, in turn, ship much of it in the form of whole milk to the cities. In each of these localities a considerable number of the various kinds of mechanical milkers was found.

LABOR REQUIREMENTS OF DAIRY FARMS.

Dairying is a type of farming which is very dependent upon labor. The degree of dependence is governed by the intensity of the dairy industry on the farm. The strictly dairy farm, the one receiving nearly its entire income from dairy stock and dairy products, if operated at full capacity, usually carries as large a dairy herd as the farm is capable of supporting.

Such a dairy farm, as commonly organized in the North Atlantic States, often receives from 90 to 95 per cent of its total income from dairy products and dairy stock. It is divided into fields and pastures which are so proportioned as to enable the farm to support a nearly uniform number of dairy animals throughout the year. Under such a farming system the labor necessary to grow and harvest the crops is not adequate to care for a herd large enough to consume them. The number of milking cows kept is one of the important factors which determine the labor required on the farm. This is due to the fact that on the type of dairy farm referred to here the labor required to milk is greater than that required for the other farm operations. Milking is conditioned both by time and physical limitations. It must be done at regular intervals and requires enough milkers to complete it within certain time limits. It is not ordinarily possible for one man to milk as many cattle as he can raise and harvest crops for and otherwise take care of. Under an intensive system of dairy farming it normally requires three men to milk by hand a herd which two men are capable of caring for otherwise. Unless there is some other enterprise which will profitably employ the extra man's time between milking intervals, there is a loss of efficiency of the labor on the farm. It is in the adjustment of this labor problem that the milking machine enters as an important factor, as a man can milk more cows in a stated time by machine than by hand. Two men operating mechanical milking units can do the work of three men milking by hand. In Cornell Bulletin No. 364, "Cost of Producing Milk on 174 Farms in Delaware County, N. Y.," the author states: "After feed, labor was the most important

cost factor in the production of milk. Excluding the hauling of milk, the labor cost represented 18.9 per cent of the total cost."

TABLE I.—*Relation between man labor employed, crops grown, and stock kept on farms in the areas studied.*

FARMS WITHOUT MILKING MACHINES.

Area.	Number of farms.	Average size (acres).	Number of men employed per farm per year.	Acres of crops raised per farm.	Acres of crops per man.	Number of dairy cows per farm.	Number of dairy cows per man.
New York	53	191.4	2.16	73.8	34.2	30.8	14.3
Michigan-Ohio and Illinois	60	146.7	2.14	90.75	42.4	20.5	9.6

FARMS WITH MILKING MACHINES.

New York	56	213.9	2.12	71.4	33.7	34.9	16.5
Michigan-Ohio and Illinois	100	166.4	2.22	98.3	44.3	23.7	10.7

As is shown in Table I, the farms studied in the Michigan-Ohio and Illinois areas have a larger proportion of their total acreage in crops than those studied in New York. They raise more crops per man employed and keep fewer dairy cows. From the standpoint of the labor they employ, their organization is much better than that of the New York dairy farm, in that there is much more uniformity between the help required to care for the herd and that needed to care for the farm crops. Even upon farms of this type, however, the milking machine has become important, owing to the scarcity of dependable farm labor and of good hand milkers.

The use of the mechanical milker did not affect the number of acres of crops cared for by one man on the farms studied in either the New York or the Central States areas, but in both of these localities a man was able to care for and milk more cows on those farms having milking machines. On the New York farms having mechanical milkers 16.5 cows were kept per man, as against 14.3 cows per man on those farms which depended upon hand milking. The farms in the Michigan-Ohio and Illinois areas having milking machines kept approximately one cow more per man employed than those without machines. The milking machine made it possible to increase the size of the dairy without increasing the amount of labor needed to care for it.

SIZE OF HERD AND LABOR REQUIREMENTS.

Table II shows that large dairy farms require proportionately less labor to operate them than do farms keeping small herds. The same fact is brought out in a different way in Table III, where it is shown that it requires more time to care for a cow in a small herd than one in a large herd.

TABLE II.—*Relation between man labor employed, size of dairy herds, and use of mechanical milkers.*

Area and size of herd.	Number of herds of each size.		Number of men employed per farm.		Number of dairy cows per farm.		Number of dairy cows per man.	
	On farms with machines.	On farms without machines.	On farms with machines.	On farms without machines.	On farms with machines.	On farms without machines.	On farms with machines.	On farms without machines.
Michigan-Ohio and Illinois area:								
15 cows or less	26	20	1.68	1.47	12.3	11.35	7.3	7.7
16 to 30 cows	54	34	2.19	2.33	22.9	22.8	10.4	9.8
31 to 50 cows	16	6	2.51	3.29	36.4	38.3	14.5	11.6
51 or more cows	[1] 3	.....	3.73	.....	55.0	.....	14.7	.....
New York area:								
15 cows or less	6	8	1.0	1.51	10.3	12.9	9.95	8.5
16 to 30 cows	18	29	1.59	1.91	21.4	23.1	13.5	12.1
31 to 50 cows	25	10	2.38	2.5	40.6	42.0	17.1	16.8
51 or more cows	[2] 6	[3] 5	2.66	3.82	68.2	72.0	21.9	18.8

[1] One farm in this group peddled milk in town and required extra labor; therefore it was not used in this table.
[2] One farm in this group made butter, which raised the labor requirement of the farm. The report was not used in this table.
[3] On a farm in this group only a small proportion of the cows kept were milked. The report was excluded from this table.

Table II also shows, under the heading "Number of men employed," that for herds of the same size slightly less labor is employed on farms where the milking machine is used. This is true in both New York and the Central States. In both sections those farms using milking machines kept about two more cows per man. The column headed "Number of dairy cows per man" refers to the number of cows kept for each man employed on the farm throughout the year. It is shown that the farms having larger herds keep more cows in proportion to the labor employed.

The amount of labor required to care for the herd and the period of the year when the labor demands are greatest are important factors in determining the labor available for other farm work. In the areas which were covered by this study it is the common practice to maintain the herds on pasture during the growing season, which may be roughly defined as between May 15 and November 1. During this period the cows demand little attention other than that required in getting them up to milk and turning them back to the pasture again, both night and morning. On most farms they are given supplementary feeds during the late summer, but this is usually in the form of grain which can be fed in a few minutes when the herd is in the stable. Occasionally some roughage is fed also. This consists mostly of green corn cut and fed in the pasture lot or stable, which operation takes considerable extra time. The time taken to feed in the summer, however, is offset by the fact that in those herds where feeding is practiced the cattle come for their feed at milking time, while in the case of the herd not fed it is necessary to go after them.

From November 1 to May 15 the cattle are stabled, and during the period they require considerable attention. In addition to feeding

the stock the stables and the cattle themselves have to be kept in a clean and sanitary condition.

Table III shows the time spent during the summer and winter seasons in the care of the herd. The table also show that there is proportionately much more labor required per cow to care for the small herds. In the New York area, on farms where hand milking is practiced, the total time spent annually to care for and milk the dairy herd was 173.7 hours per cow in the herds of 15 cows and less, as compared with 118.2 hours per cow in the herds of 51 or more cows.[1]

TABLE III.—*Hours of man labor per year required to care for and milk a cow in herds of different sizes, and when milked by hand or by a mechanical milker (hauling to market not included).*

Area and size of herd.	Number of herds of each size.		Hours of man labor per cow per year.							
			Care of cow (milking excluded).				Milking.		Total hours per year.	
			Total for pasture season.[1]		Total for remainder of year.[2]					
	On farms having machines.	On farms not having machines.	On farms having machines.	On farms not having machines.	On farms having machines.	On farms not having machines.	On farms having machines.	On farms not having machines.	On farms having machines.	On farms not having machines.
Michigan-Ohio and Illinois areas:			*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*
15 cows or less	26	20	18.6	16.9	73.75	65.6	57.2	92.95	149.55	175.45
16 to 30 cows	54	34	11.6	17.7	53.2	56.8	53.8	84.5	118.6	159.0
31 to 50 cows	16	6	7.8	5.7	46.0	49.6	53.5	85.2	107.3	140.5
51 or more cows	4	.....	15.4	.....	36.6	.....	38.0	.....	90.0	.....
New York area:										
15 cows or less	6	8	16.0	16.0	96.8	77.7	65.5	80.0	178.3	173.7
16 to 30 cows	18	29	7.3	12.6	46.1	52.9	56.1	82.0	109.5	147.5
31 to 50 cows	25	10	7.0	7.1	40.7	52.4	47.3	82.4	95.0	141.9
51 or more cows	7	6	5.7	5.6	33.5	26.3	39.7	86.3	78.9	118.2

[1] Cornell Bulletin No. 364 shows that in Delaware County, N. Y., 20 per cent of all the labor spent in the care of the herd is furnished by the women and children of the family. Proportionately more family labor is furnished on the smaller farms. The larger dairy farms are very dependent upon hired labor and it is often found difficult to secure sufficient help.

Men who are hired by periods of a month or longer are commonly employed in the care of the dairy and to milk. The average wages paid to this class of labor were very uniform in all the areas included in the study, and were as follows: In New York, $28 per month; in Illinois, $29.50 per month; and in the Michigan-Ohio area, $28.85 per month. The unmarried farm worker was furnished with his board, and the married man with a house, wood, milk, etc. Other investigations carried on by the Office of Farm Management show that the value of a farm worker's board is approximately $12 per month. The value of a tenant house, wood, milk, etc., furnished to the married farm hand is considered about equal to the value of board.

The total average value of wages and board is therefore $40.75 for all the areas.

There are 26 working days per month. It is estimated that the dairyman works 12 hours each working day. He also works 4½ hours on Sunday. This makes a total of 330 hours per month. The cost per hour of labor figured on this basis is 0.123 cent.

[2] The exact dates of stabling cattle in the fall and turning them out to pasture in the spring vary with the season and the practice of the individual dairyman. Cattle are commonly stabled from approximately November 1 until May 15, a period of 200 days. The balance of the year (165 days) they are on pasture.

The use of the mechanical milker has little, if any, bearing on the time required to care for the dairy herd other than that of milking. When the total time required to care for and milk a cow is considered, it will be noted that, with the exception of the herds of 15 cows or less in the New York area, in all cases a cow on those farms on which mechanical milkers are used requires fewer hours of labor per year. This is due to the saving in the time required to milk through the use of the milking machine.

When a cow is milked by hand more time is required for milking than for the care and feeding of the cow. As the size of the herd is increased this difference becomes greater. On the larger dairy farms using mechanical milkers the time required to milk a cow nearly equals the time required to feed and care for her. This is very similar on the New York farms studied, while on the farms studied in the Ohio, Michigan, and Illinois areas it requires somewhat less time to milk a cow than to care for and feed her.

THE MILKING MACHINE.

The milking machine had received considerable attention in Australia and New Zealand prior to its introduction in this country. In 1849 the first United States patent for a mechanical milker was issued, but the development of the milker did not reach the stage where its efficiency made it an economic factor until within recent years.

The labor problem of the dairy farm has for a long time been a troublesome one, made so by the large amount of help required to milk as compared to that needed for the other farm work. This condition, as well as the fact that excessive hand milking is not only distasteful to many dairymen but also often injurious to hands and wrists, has created a demand for an efficient and economical mechanical milker. Various State experiment stations have published bulletins treating on the efficiency of certain types of milking machine, but very little information has been made available which will show the relative cost of milking with these outfits as compared to hand milking.

The factors which determine the cost of hand milking are the time required and the cost of labor. The factors which determine the cost of milking with the mechanical milker are: Time required to operate, wages paid to operators, interest on investment in outfit, repairs, cost of power, and depreciation.

THE TIME FACTOR.

Table IV shows that on the farms keeping 15 cows or less it takes 7.3 minutes to milk a cow by hand and 4.8 minutes to milk a cow with a mechanical milker. On the farms keeping larger herds it takes

proportionately less time to milk with mechanical milkers, but where hand milking is practiced the time required to milk a cow does not vary appreciably with the size of the herd. These facts indicate that the mechanical milker may be used with more efficiency in the larger herds than in the smaller ones. The time required to milk, both by hand and by machine, was figured on the basis of the average time per milking year for each cow in each herd. In the case of machine milking this includes the time necessary to clean and care for the machine. The normal lactation period of a cow is from 9 to 11 months. Therefore the actual time required to milk per milking may be slightly higher, varying with the length of the lactation period.

TABLE IV.—*Time required per milking, by machine and by hand, for herds of different sizes in areas studied.*

Size of herd.	Hand milking.				Machine milking.			
	Number of farms.	Number of milkers per herd.	Minutes per milking per cow.	Number of cows per milker.	Number of farms.	Number of operators per herd.	Minutes per milking per cow.	Number of cows per operator.
15 cows and less	28	1.4	7.3	8.25	32	1.1	4.8	10.6
16 to 30 cows	63	2.4	6.85	9.7	72	1.5	4.45	15.3
31 to 50 cows	16	3.1	6.85	13.3	41	1.9	4.1	20.5
51 cows or more	6	4.3	7.1	17.0	11	2.4	3.2	27.8
Average	113	2.3	6.95	10.8	156	1.6	4.15	17.6

Should most of the milk from the herd be produced during the spring and summer season when the other farm work requires a maximum of attention, the time saved by the use of the milking machine may be devoted to the raising and harvesting of farm crops, thus eliminating the need for the extra day labor which is often hired for this purpose.

A comparison of the columns "Number of cows per milker" under the heading "Hand milking" and "Number of cows per operator" under the heading "Milking machine" shows that a man using a mechanical milker is capable of milking more cows than he can milk by hand. This advantage becomes important with the increase in the size of the herd.

Table V shows that on farms where milking machines are used the average farmer estimates that the use of the machine enables him to operate his farm with a saving in wages paid to hired labor. This saving is partly due to the elimination of day labor.

THE COST FACTORS.

As the use of the milking machine makes it possible for a man to milk a greater number of cows, and as very often milking is the

factor determining the labor requirement, the installation of the milking machine replaces some of the regularly employed help. The value of the labor replaced yearly by the mechanical milker varies, according to estimates made by the dairymen interviewed, from $2.63 per cow in herds of 15 cows or less to $8.33 per cow in herds of more than 50 cows. There is an addition to the time available for field work, varying from 1.5 hours of man labor per day on farms keeping herds of 15 cows or less to 5.1 hours on farms keeping herds of over 50 cows, due to the use of the milking machine. To this may be attributed, in part, the reduction in labor hired. As previously mentioned an increase in the time available for field work makes it possible to do more work with the regular force and often eliminates the necessity of hiring extra help.

TABLE V.—*Saving due to machines in time and in wages paid to hired labor as estimated by the dairymen interviewed.*

Size of herd.	Number of farms with herds of each size.	Farmers' estimate of hours of working [1] time saved by use of the mechanical milker (per day, per farm).	Estimated saving of wages paid to labor due to the use of the milking machine (per cow, per year).
15 cows or less	32	1.5	$2.63
16 to 30 cows	72	2.2	5.93
31 to 50 cows	41	3.0	4.93
51 cows or more	11	5.1	8.33

[1] Such time as is saved from milking is available for a man and team. When the laborer leaves his work to milk, if he is using a team it must be stabled; hence, man and horse time is affected, depending upon the nature of the work.

TABLE VI.—*Comparative annual costs of hand and machine milking on farms with herds of different sizes in the areas studied.*

Size of herd.	Machine milking.							Hand milking.	
	Number of farms with herds of each size.	Interest on investment (per cow).	Value of gas and oil (per cow).	Cost of repairs (per cow).	Depreciation (per cow).	Labor cost (per cow).	Total cost (per cow).	Number of farms with herds of each size.	Labor cost (per cow).
15 cows and less	32	$1.26	$0.94	$0.20	$1.98	$7.39	$11.77	28	$10.91
16 to 30 cows	72	.79	.84	.20	1.00	7.31	10.14	63	10.26
31 to 50 cows	41	.61	.84	.25	1.49	6.03	9.22	16	10.11
51 cows or more	11	.56	.83	.36	1.12	4.47	7.34	6	10.45
Average	156	.82	.86	.22	1.24	6.79	9.93	113	10.41

The labor cost of milking by hand and by machine milking is shown in Table VI. Wages are figured at 0.123 cents per hour. The labor costs conform to the time required to milk by hand and machine milking as shown in Table IV. They remain nearly the same in herds of various sizes when hand milked, but diminish in the

larger herds when the milking machine is used. Each of these items will be considered in detail.

INTEREST ON INVESTMENT.

Interest on investment is a widely variable item. When the type of milker used is the same, the investment charge per cow is much smaller in the large than the small dairies. This is because a power plant, piping, etc., have to be installed in the small as well as in the large dairy, and the difference in the costs of these equipments is not proportional to the number of cows they serve. There is considerable variation in the costs of the different kinds of mechanical milking outfits on the market. The comparatively expensive outfits are more frequently used on the farms having larger dairies; therefore, the investment per cow is not as much smaller in these large herds as it would appear that it should be.

COST OF POWER.

The cost of power per cow falls slightly as the number of cows milked increases. The time consumed per cow is greater in a small herd than in a large one.

Power for the operation of milking machines is usually furnished by means of a gasoline engine. It does not ordinarily pay to use an engine which develops much excess power, as it requires too much gasoline. Where it is necessary to pump water this is often done at milking time, and a larger engine may be profitably used to do the extra work. The cost of power furnished by a gasoline engine depends on the local prices of gasoline and oil, and the efficiency with which the engine is operated. Electric motors are sometimes used as a source of power on farms near large towns where current from a power line is available. This form of power is sometimes more expensive, but perhaps is more reliable than gasoline. In special cases, as, for example, where the herd is large and extra labor for emergency hand milking not available, it may sometimes be worth the extra investment incurred to have a second gas engine large enough to operate the milker, set up in such a manner that in case of accident to the engine regularly used it could be pressed into service without loss of time.

REPAIRS.

The repair costs seem to be greater per cow for the larger herds. This is probably due to the fact that with such herds more cows are milked with a milking unit than with the smaller herds. The repair costs are largely confined to the rubber tubing and rubber linings of the teat cups.

DEPRECIATION.

It is not possible, in view of the short time the mechanical milker has been in general use, to secure accurate data on the rate of depreciation of such machines. Some of the parts, such as the vacuum tank and the iron piping, should last almost indefinitely. The pails, if heavily nickeled or made of nickel alloy or other noncorrosive metal, should last for a number of years. The parts most subject to depreciation, the rubber tubes and teat cup rubbers, are normally subject to such frequent renewal that the cost of keeping them up has been included under repair costs. The parts always subject to a certain amount of wear are the engine, pump, and pulsator. Reliable data is at hand to justify the assumption that the depreciation of the small stationary engine averages not more than 10 per cent per year. Since the pump is much less complicated than the engine and is not subject, as is the engine, to deterioration due to excessive heat, it may be assumed that the life of the pump is somewhat longer than that of the engine. This leaves the pulsator, the cost of which is not more than 25 per cent of the total cost of installation, as the only wholly unknown quantity. All things considered, it has been thought safe to assume that the life of the outfit as a whole, not counting rubber parts, is slightly longer than the known life of the engine. Hence 8 per cent per year has been taken as the rate of depreciation of milking-machine outfits in this discussion. It should be borne in mind, however, that this figure is a somewhat arbitrary one, used in this connection only for lack of any more definite figure and that it applies to the entire outfit, exclusive of rubber parts. It was felt that the use of even this rough approximation would tend to make the results of this study more reliable than they would have been had depreciation been ignored altogether.

The depreciation charge, like the investment charge, is affected by the initial cost of the milking outfit. When an arbitrary depreciation figure is applied to all outfits the more expensive ones receive a higher depreciation charge. In actual use, however, the depreciation is determined by the initial cost and the length of life of the machine, with the last factor the more important.

COMPARATIVE COST OF MILKING BY HAND AND BY MACHINE.

As previously stated, the cost of hand milking is determined by the time taken to milk and the wages paid to the milkers. In figuring the cost of milking with the mechanical milker the following items were considered in addition to the labor cost: The interest on the investment, the fuel expense or cost of power, and the repairs and

depreciation. The actual cost of milking a cow by the two methods is shown by Table VI. The tables indicate that a cow in a herd of 30 cows or more can be milked more profitably by the mechanical milker than by hand. In the dairies of 15 cows or less the actual cost of hand milking is less than by machine milking. Table V, however, shows that the use of the machine eliminates the hiring of some help on these farms, as it permits the operator to milk alone a number of cows which he would require additional labor to milk by hand. Such a condition is found on farms where the operator has become physically unfit to milk, because of the weakening of muscles in his hands and wrists. Some farmers do not like to milk and prefer either to hire labor for this purpose or keep small dairies. The milking machine also assures the farmer of being able to do the milking in case of sickness among his working hands or if any of them should leave. In this way it makes the dairyman less dependent upon hired help.

EFFECT ON COWS.

Tests conducted by various State experimental stations show that practically the same milk yields were secured from cows whether they were machine milked or hand milked.[1] The bulletins reporting these experiments, however, emphasize the fact that when the mechanical milker is successfully operated it must be in the hands of a competent man, and that stripping after the machine is absolutely essential if satisfactory results are to be obtained. Information obtained in this study substantiates these statements.

A reasonable amount of care and intelligence must be exercised by the operator if good results are to be expected. It is not a good plan for the operator to attach a milking unit to a cow and go away while it is in operation. When the milker has drawn all the milk that will be given freely by the cow it is a saving of time to remove it and place it on the next cow to be milked. Strippings can be drawn much more quickly by hand and with less chance of injury to the cow. Many users of milking machines are of the opinion that best results are obtained from them if certain of the milking force are assigned to operate and others strip after the machine. Stripping the cows after the machine is removed not only saves time but also affords opportunity for examining the udder.

In order to ascertain the effect, if any, of the mechanical milkers on the milking qualities of cows in the dairies where they were used, two questions were asked the dairyman operating them. Following are these questions, with summaries of the answers received.

[1] Kentucky Exp. Sta. Bul. No. 186; New York Exp. Sta. Bul. No. 317 (Geneva); Wisconsin Exp. Sta. Bul. No. 173.

(1) Has the use of the mechanical milker influenced the production of your herd?

There were 156 answer as follows:

No difference.	Less.	More, if anything.
124	16	16

(2) Do you find that the machine has magnified or lessened sore teats, spider in the teats, garget, milk fever, and other udder troubles?

There were 129 answers as follows:

No difference.	Less trouble from udder diseases.	More trouble from udder diseases.
110	11	8

Thus it appears that the majority of the farmers visited believe that the milking machine has no effect one way or another in the general welfare of the herd. These figures are given merely as indicative of the trend of opinion among farmers; they are not to be taken as conclusive. A conclusive answer to these questions could be given only after a careful and comprehensive study.

EFFECT OF AGE OF COW ON EFFICIENCY OF MACHINE MILKING.

The readiness with which a herd of cows becomes accustomed to the milking machine depends upon several factors, the most important of which is the age of the animals. It is the general experience of farmers that young cows which are broken in to milk with the mechanical milker take to it more readily than older ones which have become accustomed to hand milking. They become used to it in a shorter time and milk out cleaner than older cows. Many young cows are difficult to milk by hand on account of their short teats. Short-teated cows and "hard milkers" are as easily milked by the machine as any others.

A herd which has been roughly treated becomes nervous and will not be broken in to the milking machine as readily as one which has been handled more gently. Some old cows never will become accustomed to the milking machine so as to be milked satisfactorily by it. It is best to milk such cows by hand or to sell them. On the other hand, cows averse to hand milking have been milked with good results by the mechanical milker.

STAGE OF LACTATION PERIOD.

When a cow's lactation period has so far advanced that she becomes a "stripper" many farmers think that it is a waste of time to put the milker on her. Hence it is a common practice to discontinue using the milking machine on cows that are nearly dry and strip by hand. In herds where most of the cows become nearly dry at one time the use of the mechanical milker is often discontinued altogether for a time until cows enough come in to enable the machine to be operated economically.

TABLE VII.—*Comparative efficiency of various combinations of milking units and operators in the operations of mechanical milkers.*

Number of operators [1] and millking units.	One-cow milker.		Two-cow milker.	
	Number of farms.	Minutes per cow per milking.	Number of farms.	Minutes per cow per milking.
1 operator, 1 milker	.....	.....	14	4.75
1 operator, 2 milkers	28	4	19	3.35
1 operator, 3 milkers	7	3.65	.....	.....
2 operators, 2 milkers	10	5.25	24	4.45
2 operators, 3 milkers	21	5.2	.....	.....
2 operators, 4 milkers	11	4.85	.....	.....
3 operators, 3 milkers	4	5.3	.....	.....

[1] The term "Number of operators" as used in the above table means the number of men who either operate the machine or strip.

EFFICIENCY OF MILKING COMBINATIONS.

Of the different kinds of milking machines in common use about half milk one cow at a time and the other half two cows at a time. They are called, respectively, one and two unit outfits. Each has certain advantages.

Table VII was made by averaging the time taken to milk a cow by the several combinations of milking units and operators most commonly used. This table indicates that the greatest speed in milking is made when one man operates and strips after two double milking units. On farms where one man operates and strips after three units the cows must be stripped hurriedly. Too rapid stripping is not desirable when it is done at the expense of the thoroughness of the work.

There are various conditions, however, which will determine what is the best combination to use in milking. The ability of the operators to change the machines and attend to the cows, the readiness with which the cows let down their milk, and the time required to strip, all enter into the determination of the best milking combination.

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